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July 8, 2008

Rec'd 7/8/08

VIA HAND-DELIVERY

Ms. Victoria J. Rutson
Chief, Section of Environmental Analysis
Surface Transportation Board
395 E Street, S.W.
Room 1106
Washington, D.C. 20423

Re: Finance Docket No. 34658, The Alaska Railroad Corp. -- Petition For Exemption From 49 U.S.C. §10901 To Construct and Operate a Rail Line Between North Pole, Alaska and Delta Junction

Dear Ms. Rutson:

On behalf of the Alaska Railroad Corporation ("ARRC"), enclosed for your information please find in hard copy and on CD the "Wetland Functional Assessment Report, June 2008" prepared by HDR Engineering, Inc. in connection with the above-captioned proceeding.

Please let me know if you have any questions.

Sincerely,

Kathryn Kusske Floyd

Kathryn Kusske Floyd

Enclosure

cc: David C. Navecky, SEA
Alan Summerville, ICF
Brian Lindamood, ARRC (w/o encl.)

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Northern Rail Extension Project

Wetland Functional Assessment

June 2008

Prepared for:

Alaska Railroad Corporation
327 West Ship Creek Avenue
Anchorage, Alaska 99501

Prepared by:

HDR Alaska, Inc.
2525 C Street, Suite 305
Anchorage, Alaska 99503

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1.0 Introduction and Purpose

The purpose of this report is to describe functions of wetlands located within the proposed corridor of the Alaska Railroad Corporation's (ARRC) Northern Rail Extension Project. Wetland locations and characteristics are defined in the Preliminary Jurisdictional Determination (PJD) (HDR 2008). The proposed corridor is located in interior Alaska in the vicinity of the Tanana River between the communities of North Pole and Delta Junction, Alaska. The proposed corridor covers all of the currently proposed 14 alignment segments. These alignment segments can be pieced together to make up the various alternatives. The corridor is predominantly undeveloped rural lands and extends approximately 80 miles.

One consideration for selection of build alternatives is the presence of wetlands and other waters of the United States. Wetlands and other waters of the U.S. are subject to the jurisdiction of the U.S. Army Corps of Engineers (USACE) under authority of Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act of 1899. The USACE has authority over certain work in "other waters of the U.S.," including wetlands, and in "navigable" waters. By federal law (Clean Water Act) and associated policy, it is necessary to avoid project impacts to wetlands wherever practicable, minimize impact where impact is not avoidable, and in some cases compensate for the impact. This document is a tool that the USACE can use to analyze impacts to wetlands and their associated functions. Analysis of potential wetland-related impacts will be ongoing during the development of project alternatives.

Wetlands, other waters of the U.S., and uplands (non-wetlands), as referenced in this report, are defined as:

Wetlands. "Those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions" (33 Code of Federal Regulations [CFR] Part 328.3(b) 1986). This also includes atypical situations, defined as "areas in which one or more parameters (vegetation, soil, and/or hydrology) have been sufficiently altered by recent human activities or natural events to preclude the presence of wetland indicators of the parameter" (USACE 1987). Wetlands are a subset of "other waters of the U.S." Note that the "wetlands" definition does not include unvegetated areas such as streams and ponds.

Other waters of the U.S. Other waters of the U.S. include all waterbodies and areas below their ordinary high water mark, such as lakes, rivers, gravel bars, ponds, and streams, in addition to wetlands. The ponds mapped in the project area are "other waters of the U.S." but not "wetlands".

Uplands. Non-water and non-wetland areas are called uplands.

As described in the 1987 U.S. Army Corps of Engineers wetlands delineation manual (USACE 1987), wetlands must possess the following three characteristics:

- *Hydrophytic Vegetation:* Vegetation community dominated by plant species that are typically adapted for life in saturated soils.

- *Wetland Hydrology:* Inundation or saturation of the soil during the growing season.

- *Hydric Soils:* Soils that are saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions.

2.0 Preliminary Jurisdictional Determination

In January 2008, a PJD was prepared for the project based on fieldwork completed in the summers of 2005, 2006, and 2007 (HDR 2008). The purpose of the PJD was to describe the wetland identification process and describe the extent and types of wetlands and other jurisdictional waters found within the study area. Wetland types were classified using the National Wetland Inventory (NWI) Cowardin System names (Cowardin *et al.* 1979). Cowardin classification of each mapped unit included the appropriate System, Subsystem, Class, Subclass, and Water Regime. These wetland types are defined in the PJD and are used to group wetlands into categories for the functional assessment.

3.0 Wetland Functions

Wetland functions are the chemical, physical, and biological processes or attributes that contribute to the self-maintenance of a wetland and relate to the ecological significance of wetland properties without regard to subjective human values (American Society for Testing Materials (ASTM) 1999). Not all wetlands perform all functions, nor do they perform all functions to the same extent. For example, the geographic location may determine a wetland's hydrologic or water quality functions. The principal factors that determine how a wetland performs these functions are climatic conditions, quantity and quality of water entering and leaving the wetland, and disturbances or alteration within the wetland or the surrounding ecosystem (Novitzki *et al.* 1997).

Wetland functions were assessed using methods described in "A Rapid Procedure for Assessing Wetland Functional Capacity – Based on Hydrogeomorphic (HGM) Classification" (Magee and Hollands 1998). This method estimates a wetland's capacity to perform eight different functions. These functions include:

- modification of groundwater discharge
- modification of groundwater recharge
- storm and flood water storage
- modification of stream flow
- modification of water quality
- export of detritus
- contribution to abundance and diversity of wetland vegetation
- contribution to abundance and diversity of wetland fauna

Magee and Hollands Wetland Inventory Forms were used for the 2005 field effort (Magee and Hollands 1998). In 2006 and 2007, wetland teams used a modified version which combined best professional judgment (BPJ) with the Magee and Hollands method. The 2006 and 2007 forms, along with aerial photograph interpretation, were used to supply the same data as collected during the 2005 field effort. The following sections include the model results for the eight functions based on 281 wetland plot locations sampled between 2005 and 2007. Model results estimate a wetland's capacity to perform each function.

The Magee and Hollands model results are given on a scale of 0 to 1 based on information collected in the field. First, the model characterizes wetlands by whether they meet the criteria for having a direct indicator of disfunction or a direct indicator of function. If a wetland has a direct indicator of disfunction, it is automatically given a functional capacity (FC) of 0, meaning the potential for a wetland to perform that function is low. If a wetland has a direct indicator of function, it is automatically given the maximum value of 1, meaning that there is a high probability that the wetland performs that function. Wetlands that do not have either of these direct indicators are given a FC based on primary variables that are indirect indicators of the function. Primary variables each receive a specified point value, usually between 0 and 3. Then, the primary variables are summed and divided by the total possible points to calculate the FC. The primary variables are described in detail in the discussion of each function and in Appendix A.

Modifications of the model were applied to make the model consistent and useable for the Northern Rail Extension project data. The HGM model contains six different wetland classes: Flat, Depressional, Slope, Lacustrine Fringe, Extensive Peatland, and Riverine. Although data were collected in five of the HGM classes (no points were collected in extensive peatlands), all wetland sites were run through the flat HGM model. The vast majority (172) of the wetlands fell into the flat HGM class with most of the remaining sites (71) in the Depressional HGM class. The remaining 38 sites were distributed among the Slope (19), Riverine (16), and Lacustrine Fringe (3) HGM classes. The flat and depressional models are extremely similar with only slight differences (one variable) in storm and floodwater storage and contribution to abundance and diversity of wetland fauna functions. The flat class best characterizes the Tanana Valley floodplain as a whole and corresponds to what field teams experienced on the ground. "Flat" is also an inclusive regional term that includes all other HGM classes. Flat HGM types include all vegetation communities, soil types, and hydrologic regimes (Magee and Hollands 1998). These facts, coupled with the need for consistency and the small sample size of the other HGM classes, justified using the same model for all wetlands.

In addition, the assessment method used was intended to identify the functional capacities of only vegetated wetlands occurring in the project corridor and not of other jurisdictional waters of the U.S. (i.e., ponds, streams, and lakes).

Other modifications to the model included removing variables from the calculations if they were not collected. If a given variable was skipped, not answered, or unobtainable, the variable was eliminated from the model for that particular site, as per model instructions. Primarily this applies to the questions regarding nested piezometer data, which was not available for our sample sites. The omission of these variables ensured that the wetland would not be given a lower FC due to lack of information. Instead, the other variables were given a higher weight for that particular function.

Due to the project corridor length and large number of polygons mapped (4,740); it was not practicable to assess wetland functional capacity at each distinct wetland polygon. Instead, function assessment forms were completed at representative wetland types situated across the 80-mile-long project corridor. A range of FC indices for each function evaluated occurred among the sampled wetland types. This range is related to a variety of factors, including but not limited to: watershed and landform position, soil type, plant community structure, water source, proximity to a stream, and hydrologic regime.

Among the variables used to estimate each function, some variables had higher relative importance in shaping the range, whether narrow or wide, of FC indices across different wetland types. This is related to similarities of some variables seen across the project corridor. At many sites, subsets of the variables were nearly identical, resulting in only small variations among the sites' FCs. In those situations, often one or two variables were then responsible for all the differences among wetland types. These variables differed among functions and wetland types.

The presence of an outlet is an important criterion for many of the functions. For the functions storm and flood water storage, modification of stream flow, and export of detritus it is either a direct indicator of function or a direct indicator of disfunction. Wetlands without an outlet are given the maximum FC for storm and flood water storage and the minimum FC for modification of stream flow and export of detritus. Since a large percentage of the sites do not have an outlet, each model was run on only those sites that had an outlet. This more accurately discerns the functions of wetland types both with and without outlets. To apply this to wetlands within the study area, all wetland polygons were attributed with an outlet status using a geographic information system (GIS). Within the wetland mapping boundaries, all HDR-mapped streams were buffered by 100 feet. Outside of the wetland mapping, a 100-foot buffer was applied to streams within the National Hydrography Dataset (USGS 1999). Any wetland within the 100-foot buffer was considered to have an outlet. Any wetland outside of the 100-foot buffer was considered to not have an outlet. Outlet attributes were given to the portion of the wetland polygon that was inside of the buffer.

For the purpose of this report, the models' results for each function were grouped by mapped wetland type, reflecting primary vegetation type and water regime (i.e., broadleaf (BL) shrub semipermanently flooded, needleleaf (NL) forest saturated, etc.). These groups are described in detail in the PJD (HDR 2008). Using these groups, the results were extrapolated to corresponding mapped wetland types over the entire study area. This permits project planners to take measures, where practicable upland-only options are not feasible, avoiding and minimizing impacts to wetland types that have a higher capacity to perform selected functions than do other nearby wetland types.

3.1 Function 1: Modification of Ground Water Discharge

Definition:
The capacity of a wetland to influence the amount of water moving from groundwater to surface water (Magee and Hollands 1998).

Model Results:

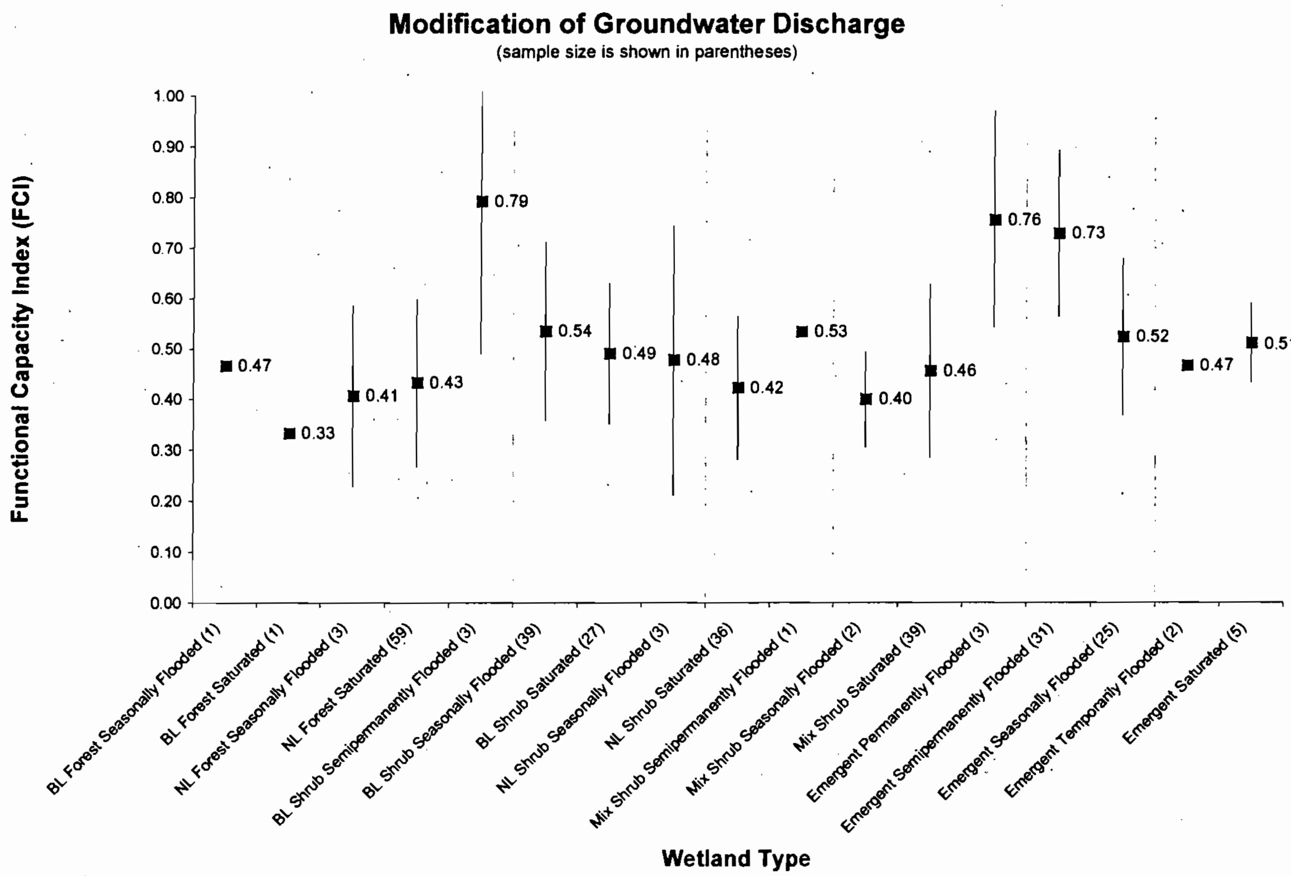

Table 1. Variables Used in Model Calculations for Groundwater Discharge*

	Indicator of Disfunction	Direct Indicator of Function	Point Value
Inlet/Outlet Class: Perennial inlet/no outlet	X		
Inlet/Outlet Class: No inlet/perennial outlet		X	
Presence of Seeps and Springs		X	
Inlet/Outlet Class: Perennial inlet/perennial outlet Intermittent inlet/perennial outlet All other classes			0-3
Surficial Geologic Deposit Under Wetland			0-3
Wetland Water Regime			0-3
Soil Type			1-3
Microrelief of Wetland Surface			0-3

*see Appendix A for a detailed description of model parameters

Discussion:

Groundwater discharge refers to the net upward vertical movement of water from an aquifer to the surface (Mitsch and Gosselink 1993). It can seep from an unconfined aquifer or flow from a confined (artesian) aquifer that intersects the ground surface. Groundwater discharge is an important function that stabilizes water levels and facilitates ecological processes such as fish spawning, rearing and overwintering (Post 1996). Most groundwater discharge wetlands fall into two categories: groundwater depressional wetlands and groundwater seep or spring wetlands. The groundwater depressional wetlands occur when the surface water level of a wetland is at a lower elevation than the surrounding areas' water table. The seep or spring wetland occurs at the base of steep slopes where groundwater intersects the land surface. However, in interior Alaska groundwater hydrology is altered due to the existence of permafrost. Permafrost acts as a giant aquitard greatly restricting the discharge and recharge of groundwater throughout the area.

The study area for the Northern Rail Extension Project is situated in the Tanana River Basin, an area of discontinuous permafrost. Most of the permafrost in the area occurs as numerous isolated deposits surrounded by coarse grained deposits. Areas lacking permafrost are under lakes, present and historic sloughs, streams and large rivers. In general, gravel layers are well drained and remain unfrozen while sand and silt layers are poorly drained and create optimal permafrost conditions. The unfrozen gravel sediments in the Tanana floodplain occur as lenses rather than extensive layers, creating a large irregular network of unfrozen passages throughout the floodplain (Hopkins *et al.* 1955). Due to these passages, as well as the numerous lakes and streams, subpermafrost and suprapermafrost groundwater circulates freely within the area.

Suprapermafrost groundwater or groundwater that collects on top of permafrost is usually discharged at the base of bog-like slopes during the spring. Snowmelt and rainfall quickly infiltrate the peat layer on slopes and then flow downhill discharging to shrub/sedge tussock vegetation or sedge tussock vegetation. The small water storage capacity of the shallow active layer of the up-gradient permafrost slopes limits the extent and periods of discharge of suprapermafrost groundwater (Post 1996).

Subpermafrost groundwater is discharged in areas where there is a direct connection to the ground surface. Groundwater discharge areas include perennial springs, lakes, ponds, and streams. Therefore, wetlands directly adjacent to or covering the surface of these waterbodies perform this function (Post 1996).

In low-lying areas of the Tanana Valley underlain by permafrost, the typical vegetation community is a saturated black spruce wetland. These black spruce wetlands are ombrotrophic, meaning the water that wets them is derived primarily from precipitation, generally not from inflowing surface water or groundwater (Post 1996). Therefore the majority of these areas do not perform the groundwater discharge function.

A study of fens covering an area just north of the Northern Rail Extension Project area concluded that vegetated mat wetlands located between forested uplands and wetlands perform groundwater discharge. Vegetation communities were dominated by sedges (*Carex aquatilis* and *Carex rostrata*), grasses (*Glyceria pulchella* and *Calamagrostis canadensis*), swamp horsetail (*Equisetum fluviatile*) and herbaceous broadleaf forbs such as buckbean (*Menyanthes trifoliata*), marsh five-finger (*Comarum palustris*) and water hemlock (*Cicuta mackenziana*) (Racine and Walters 1991).

The groundwater discharge functional capacity indices for each vegetation type and water regime are shown in the model results. The variables used in the model are shown in Table 1. Of the 281 wetland sites where functional data were collected, 19 sites had a direct indicator of this function. Direct indicators include the presence of seeps and springs and wetlands that have no inlet but a perennial outlet. One wetland site had an indicator of disfunction because it had a perennial inlet and no outlet. The remaining 261 sites received a score between 0.20 and 0.93.

On the whole, the FCs for this function in the study area were moderate. The driving factors behind the differing indices were primarily the presence of permafrost and the hydrologic regime. Wetlands that have highly permeable soils (i.e., with no permafrost) and are wet (semipermanently flooded and permanently flooded) have the highest value. If a wetland is flooded for the majority of the year and is underlain by permeable substrate the HGM model rates those wetlands as having a high probability of performing the groundwater discharge function. All other wetlands had a moderate FC of approximately 0.5. Vegetation type or structure is not included among the variables for this function (other than more emergent wetlands are found in the wetter wetlands).

The model tended to give a higher FC value to wetlands with a permanently flooded and semipermanently flooded water regime. The model assumes that a wetland that is dry or only wet for short periods of time is losing water to groundwater, whereas, wetlands that are wetter are perennially receiving water from groundwater. In order to consider the affect of water regime on the FC of a wetland, wetlands were grouped by water regime for a separate analysis (Table 2). Permanently flooded and semipermanently flooded wetlands have a higher FC for groundwater discharge than drier water regimes. This appears to be the driving factor in determining the differences in a wetlands' FC for groundwater discharge in the study area.

Table 2. Groundwater Discharge Model Results by Water Regime

Water Regime	Sample Size	Average FC for Groundwater Discharge
Permanently Flooded	3	0.76
Semipermanently Flooded	35	0.73
Seasonally Flooded	73	0.52
Temporarily Flooded	2	0.47
Saturated	167	0.45

The Magee and Hollands model was established for previously glaciated regions of the Northeastern United States and therefore is not set up to represent interior Alaska and regions of discontinuous permafrost. The permafrost restricts groundwater discharge in some areas because it is an impermeable layer. In the model, the surficial geologic deposit variable has three possible categories: high permeability, low permeability and glacial till. Wetlands underlain by permafrost were considered to have the equivalent of glacial till due to its having the lowest permeability of the three choices. In the model, this means that the wetland can still carry out this function at a limited capacity, resulting in indices from 0-0.5. However, most of the wetlands over permafrost in interior Alaska get their water from precipitation and do not perform the groundwater discharge function. Therefore, the model likely overestimates the groundwater discharge function to wetlands that are underlain by permafrost.

3.2 Function 2: Modification of Ground Water Recharge

Definition:
The capacity of a wetland to influence the amount of water moving from surface water to groundwater (Magee and Hollands 1998).

Model Results:

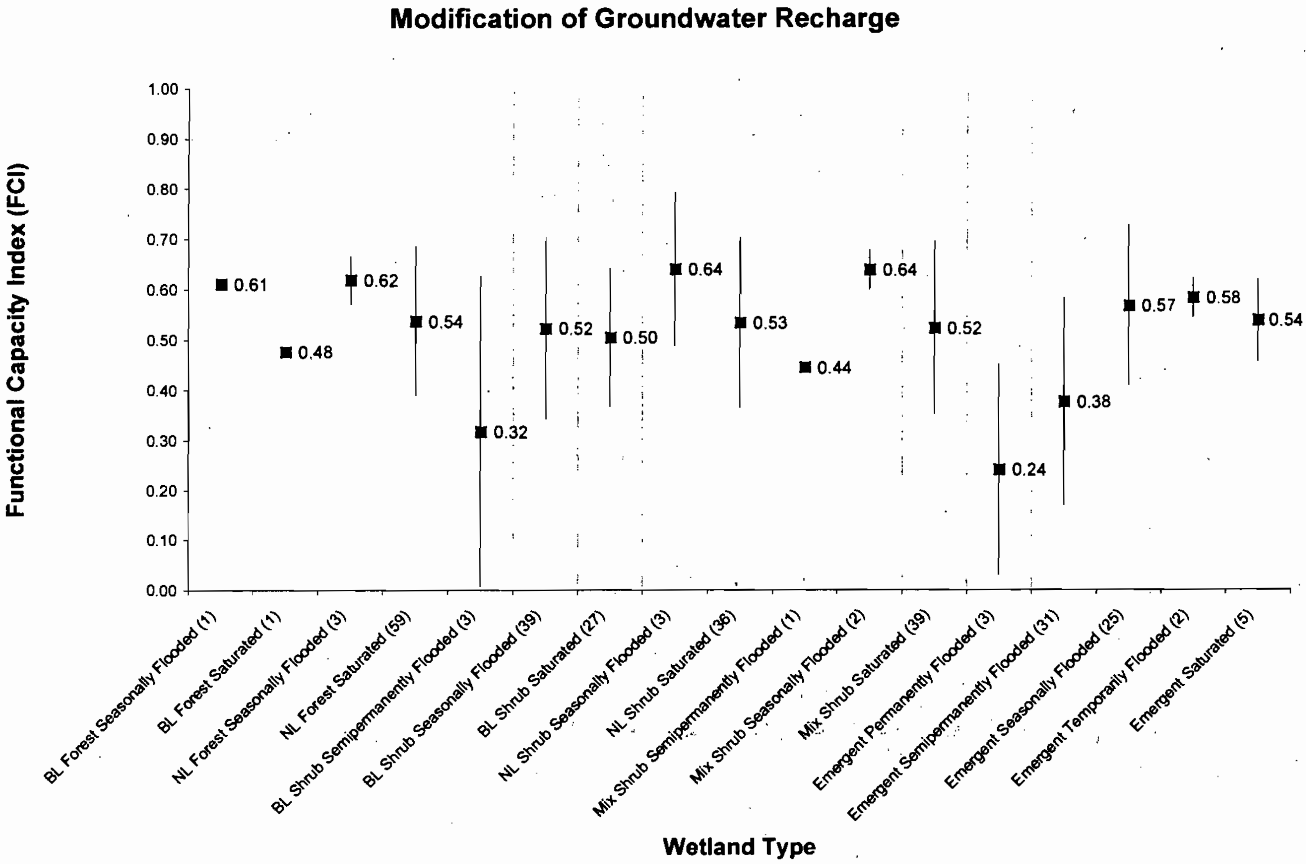

Table 3. Variables Used in Model Calculations for Groundwater Recharge

	Indicator of Disfunction	Direct Indicator of Function	Point Value
Inlet/Outlet Class: No inlet/perennial outlet Intermittent inlet/ perennial outlet	X		
Presence of Seeps and Springs	X		
Inlet/Outlet Class: Perennial inlet/no outlet			
Inlet/Outlet Class: Perennial inlet/intermittent outlet All other classes			0-3
Surficial Geologic Deposit Under Wetland			1-3
Wetland Water Regime			1-3
Soil Type			0-3
Microrelief of Wetland Surface			1-3

Discussion:

Permafrost also limits the capacity for wetlands to perform the groundwater recharge function. In wetlands underlain by permafrost, the highly decomposed peat that lies on the surface of the permafrost has extremely low hydraulic conductivity. The dense peat layer minimizes lateral and vertical water flow of perched water above the permafrost. This limits recharge to only suprapermafrost groundwater, and the magnitude of this recharge is generally quite small (Post 1996).

Most recharge of subpermafrost groundwater in interior Alaska occurs in unfrozen uplands, such as south-facing slopes, and in alluvial aquifers by infiltration from larger rivers, like the Tanana River (Post 1996). The majority of the rainfall falls in mountainous areas underlain by bedrock and is directed as runoff to the streams. The streams then flow out of the mountains across permeable alluvial fans, such as those in the Tanana Basin. These streams lose large amounts of water to aquifers because the water table is much lower than the bed of the streams (Anderson 1970).

Examples of streams losing water to groundwater include Jarvis Creek and the Tanana River. Jarvis Creek is located just south of Delta Junction and on average loses 6.5 million gallons of water per day per linear mile of channel (Anderson 1970). The Tanana River, in a section just south of Fairbanks, loses water which flows northwestward and discharges into the Chena River (Glass *et al.* 1996).

The Magee and Hollands model directly correlates the groundwater recharge function with the groundwater discharge. The Magee and Hollands model assumes that most wetlands alternate between recharge and discharge conditions. Wetlands with a high FC for groundwater discharge have a low FC for groundwater recharge and vice versa. Only one wetland studied had a perennial inlet and no outlet, a direct indicator of groundwater recharge. Direct indicators of disfunction are wetlands with an intermittent inlet and a perennial outlet, wetlands with no inlet and a perennial outlet, and wetlands with the evidence of seeps and springs. Twenty data collection sites showed direct indicators of disfunction. The remaining sites had FCs that ranged from 0.28 to 0.78.

Like groundwater recharge, the variables that are responsible for most of the difference between wetland types are the wetness of the wetland and the underlying surficial geologic deposit. The drier the wetland and the less permeable the underlying substrate, the higher a value for groundwater recharge the wetland will receive. If a wetland is drier or wet for only short intervals it is likely that water is leaving the wetland and slowly returning to nearby aquifers. Therefore the results of this model are the inverse of groundwater discharge with permanently flooded and semipermanently flooded wetlands having a low FC and drier water regimes having a moderate FC (see Table 4).

Table 4. Groundwater Recharge Model Results by Water Regime

Water Regime	Sample Size	Average FC for Groundwater Discharge
Permanently Flooded	3	0.24
Semipermanently Flooded	35	0.37
Seasonally Flooded	73	0.55
Temporarily Flooded	2	0.58
Saturated	167	0.53

As with the groundwater discharge function, the groundwater recharge model overestimated the probability of wetlands performing this function due to the presence of permafrost. Permafrost wetlands are in all likelihood not performing this function to a high degree. Areas around streams most likely are. This comes across in the model, with the highest functional capacity indices being seasonally flooded wetlands, which are typically located adjacent to streams.

3.3 Function 3: Storm and Flood Water Storage

Definition:
The storage of inflowing water from storm events or flooding events, resulting in detention and retention of water on the wetland surface (Magee and Hollands 1998).

Model Results:

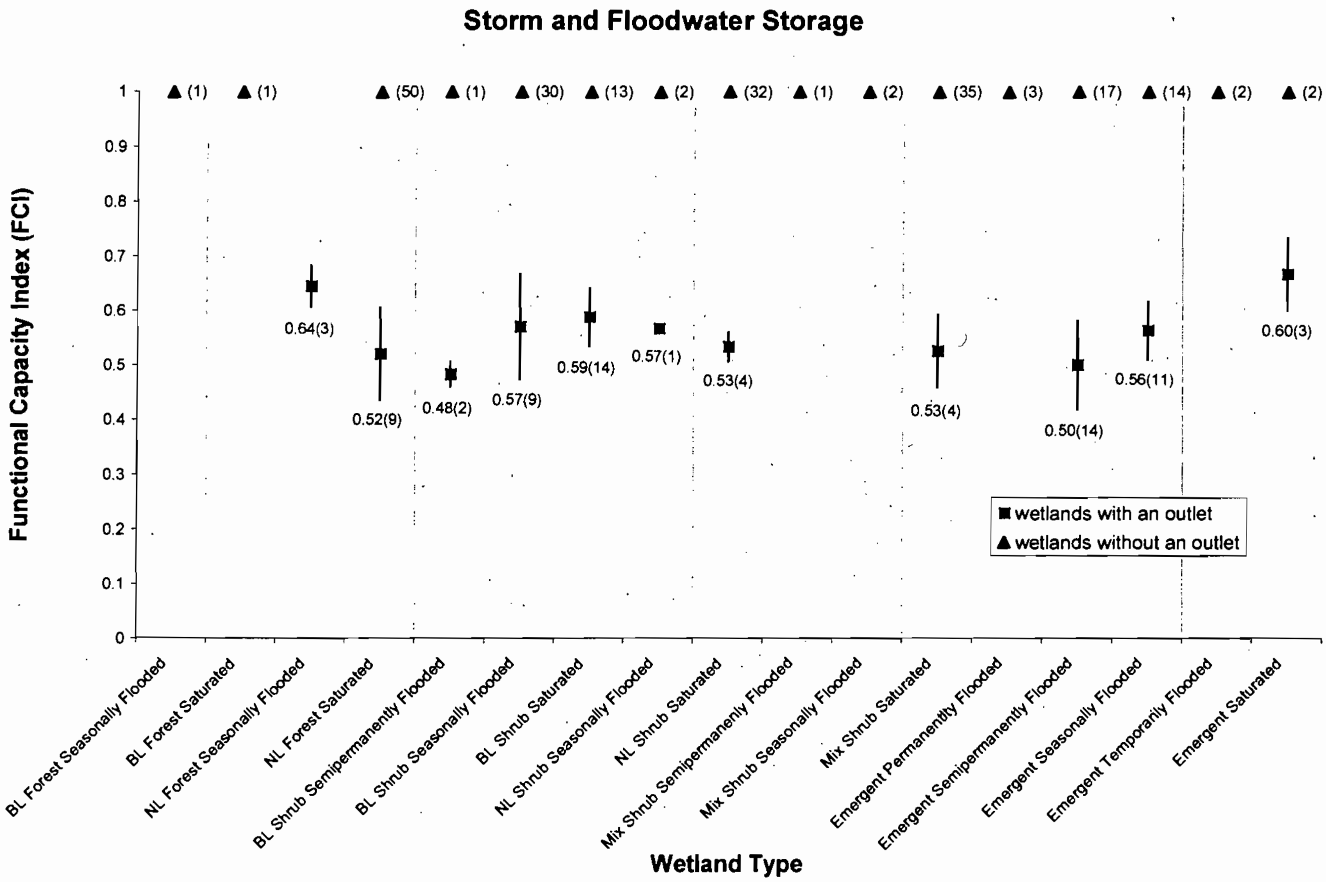

Table 5. Variables Used in Model Calculations for Storm and Flood Water Storage

	Indicator of Disfunction	Direct Indicator of Function	Point Value
Inlet/Outlet Class: No outlet		X	
Inlet/Outlet Class: Perennial inlet/intermittent outlet Intermittent inlet/intermittent outlet No inlet/intermittent outlet No inlet/perennial outlet Intermittent inlet/perennial outlet Perennial inlet/perennial outlet			1-3
Degree of Outlet Restriction			0-3
Basin Topographic Gradient			1-3
Wetland Water Regime			1-3
Surface Water Level Fluctuation of the Wetland			0-3
Ratio of Wetland Area to Watershed Area			1-3
Microrelief of Wetland Surface			0-3
Frequency of Overbank Flooding			0-3
Vegetation Density/Dominance			0-3
Dead Woody Material			1-3

Discussion:

Storm and flood water storage refers to the ability of a wetland to intercept, detain and retain water on the wetland's surface. By storing storm and flood waters, wetlands greatly reduce peak flows leading to slower discharges over a longer period of time. Therefore, the larger the wetland area, the smaller the danger of flooding downstream (Novitzki 1979; Verry and Boelter 1979). A study of the Chesapeake Bay drainage basin showed the importance of wetlands for flood flow detention. The Chesapeake Bay drainage basin has a wetland area of approximately 4%. When compared to other drainage basins with no wetland area, the flood flows of the Chesapeake Bay drainage basin were about 50% of the basins with no wetland storage (Novitzki 1985).

There are no direct indicators of disfunction for this model. Not having an outlet was a direct indicator of this function. The majority (201 sites, 72%) of the sites did not have an outlet, and therefore received a FC of 1.0. These sites are not included in the calculations because they positively bias the mean FC values. The remaining sites had an FC value between. 0.37 and 0.73.

Most wetlands in the study area have a high capacity to perform this function. This is due to the majority of wetlands lacking an outlet and the presence of peat soils. Peat soils generally consist of two layers, the acrotelm and the catotelm. The acrotelm is the upper aerobic layer of peat that is partly living and highly permeable. The catotelm is the highly decomposed lower layer of peat that has low hydraulic conductivity (Post 1996). The acrotelm quickly absorbs any surface water limiting the ability for the wetland to have surface water and placing the majority of wetlands in the saturated water regime. The uppermost peat layer of these wetlands is responsible for the high values of storm and flood water storage across the vegetation types.

Wetlands with an outlet (28%) have a moderate capacity to store storm and flood flows in the project area. The primary variable driving the minimal differences in this subset is the water regime. Drier wetlands have slightly higher values and wetter wetlands have lower values. Wetlands that are inundated for long portions of the growing season have a lower probability of being able to detain or retain storm flows, because they are already at full storage capacity. It is important to note that the model is not making any assumptions about subsurface detention of water.

3.4 Function 4: Modification of Stream Flow

Definition:
The modification of inflow hydrology by the wetland to produce the outlet stream's hydrology (Magee and Hollands 1998).

Model Results:

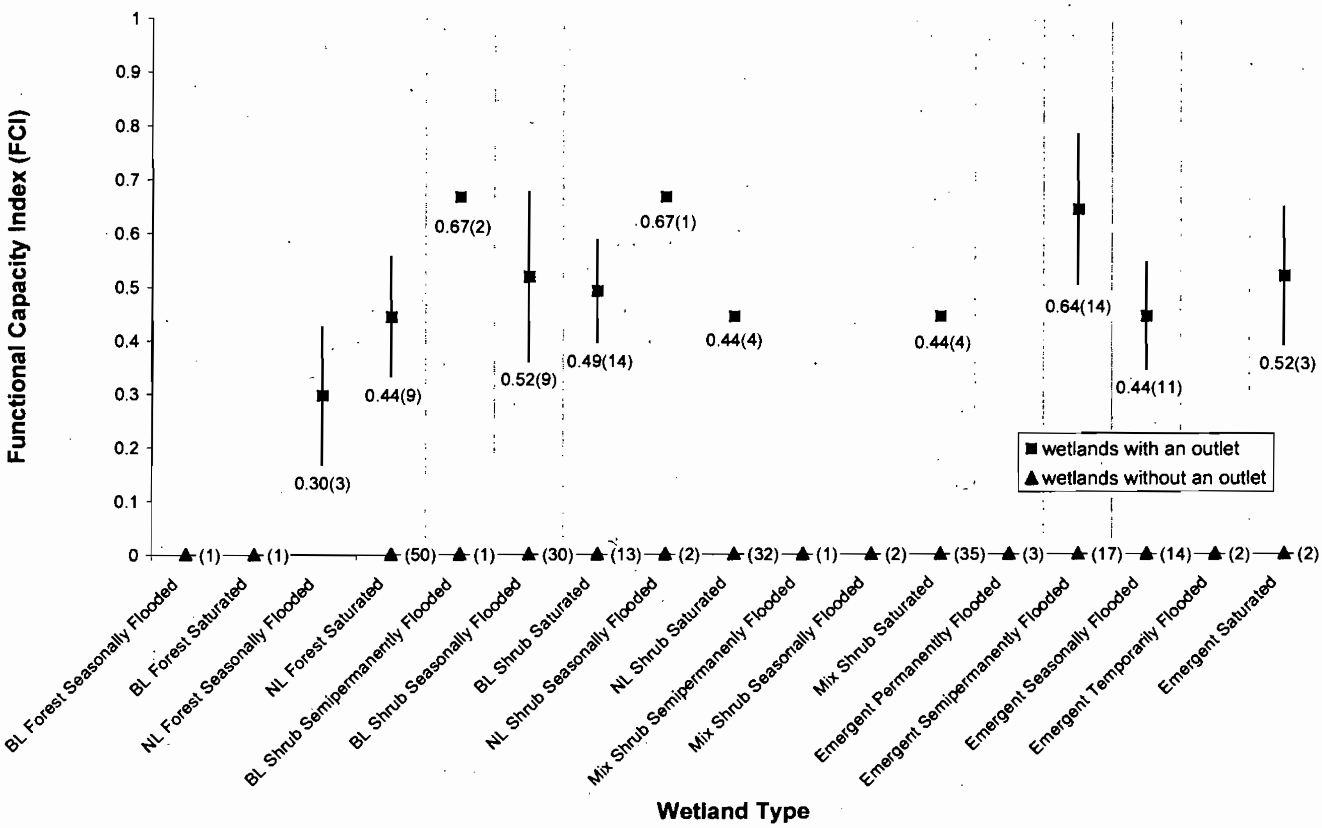

Table 6. Variables Used in Model Calculations for Modification of Stream Flow

	Indicator of Disfunction	Direct Indicator of Function	Point Value
Outlet Class: No outlet	X		
Output from Modification of Groundwater Discharge Model			1-3
Output from Storm and Flood Water Storage Model			1-3

Discussion:

The modification of stream flow function is based on the output of two previous models: modification of groundwater discharge and storm and flood water storage. The model assumes that the base flow of a stream's hydrograph is dependent on the wetland soils to modify groundwater discharge. The storm flow portion of an outlet stream's hydrograph is dependent on the wetlands' ability to retain and detain surface water. Combining these two functions accounts for the entire outlet stream's hydrology. The variables of this function are multiplied by one another, rather than added, as in all other function models.

The indicator of disfunction for this model is the lack of an outlet. The majority of wetland sites (201 sites, 72%) visited during the field effort had no outlet and were given a FC of zero. These sites are not included in the model results because they negatively bias the mean FC values of the wetlands with an outlet. The remaining sites had an FC value between 0.22 and 1.0. The model shows that semipermently flooded wetlands tend to have a higher FCs for modification of stream flow than drier water regimes. To see the affect of only water regime, all wetlands with outlets were grouped by water regime (Table 7). Semipermanently flooded wetlands with an outlet have a higher FC than other drier wetland types that also have an outlet.

Table 7. Modification of Stream Flow by Water Regime

Water Regime	Sample Size	Average FC for Modification of Stream Flow*
Semipermanently Flooded	16	0.65
Seasonally Flooded	24	0.46
Saturated	34	0.49

*wetlands with an outlet

Since this model is a compilation of the modification of groundwater discharge model and the storm and floodwater storage, it is understandable that semipermently flooded wetlands have higher FCs. For modification of groundwater discharge, the permanently flooded and semipermently flooded wetlands had high FCs, while for storm and floodwater storage, all wetlands had moderate values.

3.5 Function 5: Modification of Water Quality

Definition:
Removal of suspended and dissolved solids from surface water and dissolved solids from groundwater and conversion into other forms, plant or animal biomass, or gases (Magee and Hollands 1998).

Model Results:

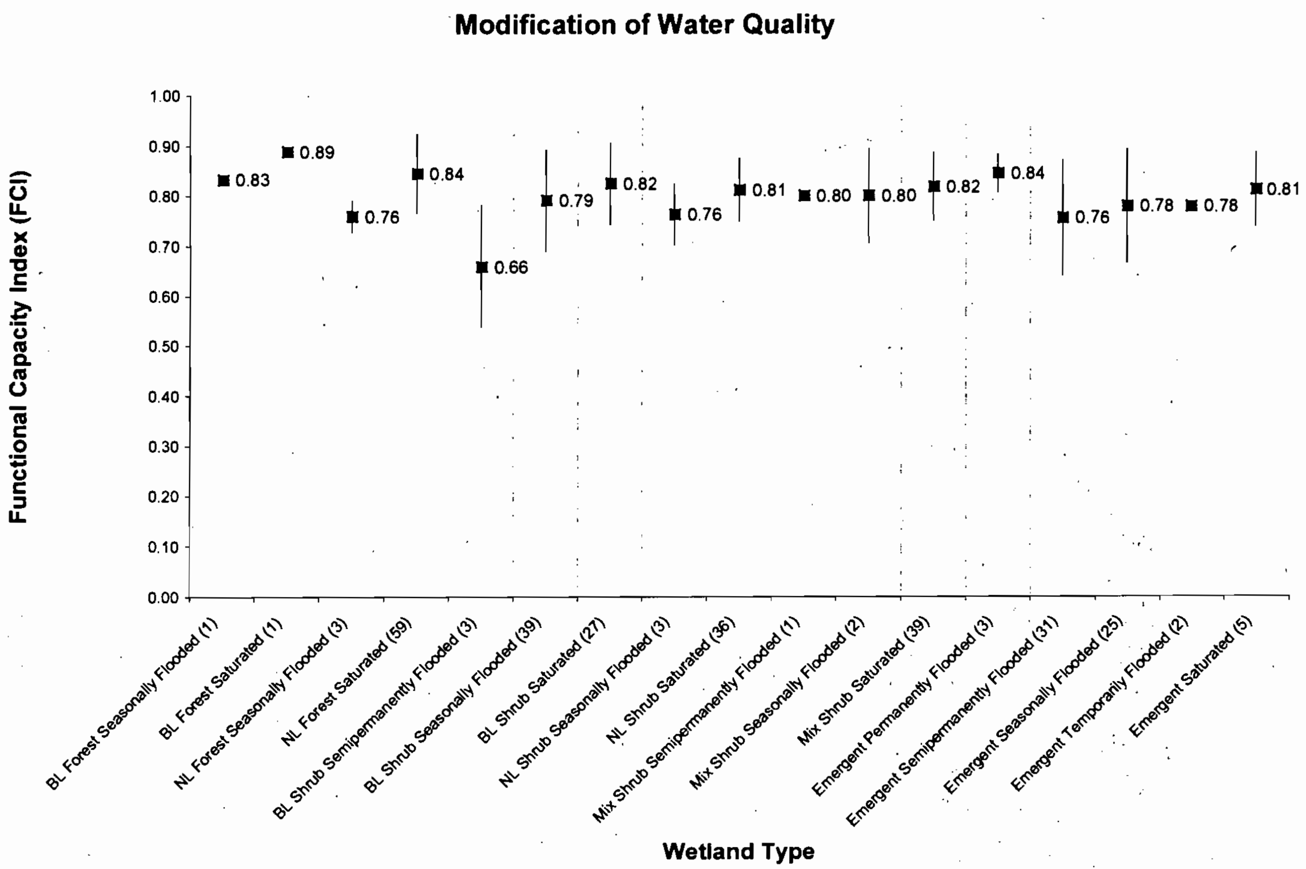

Table 8. Variables Used in Model Calculations for Modification of Water Quality

	Indicator of Disfunction	Direct Indicator of Function	Point Value
Evidence of Sedimentation		X	
Wetland Land Use			1-3
Degree of Outlet Restriction			1-3
Outlet Class: No outlet Intermittent outlet Perennial outlet			1-3
Dominant Wetland Type			0-3
Soil Type			0-3
Wetland Water Regime			0-3
Soil Type			1-3

Discussion:

Many wetlands have the capacity to modify the quality of water that flows through them. Wetlands have been shown to remove organic and inorganic nutrients and toxic material from water that flows across them. This occurs for several reasons: (1) water velocity is reduced as streams enter wetlands, causing sediments and chemicals to drop out of the water column; (2) anaerobic and aerobic processes occur in close proximity, promoting denitrification, chemical precipitation, and other chemical reactions that remove certain chemicals from water; (3) the high rate of productivity of many wetlands leads to high rates of mineral uptake by vegetation and subsequent burial in sediments when the plants die; (4) a diversity of decomposers and decomposition processes occur in wetland sediments; (5) an increase in the amount of surface contact between water and sediments leads to significant sediment-water exchange; (6) the accumulation of organic peat causes the permanent burial of chemicals (Mitsch and Gosselink 1993).

The Magee and Hollands model bases a wetland's performance of this function on the residence time of water in the wetland and sheet flow versus channelized flow. There was little variation among the variables for this model. Major differences between the wetland types can be attributed to higher point values given to forested wetlands, wetlands with no outlet, and wetlands with histosols or clayey soils. The model results suggest that almost all wetlands in the study area have a high probability of performing this function. There were no direct indicators of disfunction. The direct indicator of function was evidence of sedimentation; however, this information was not collected in 2006. Eight sites in 2005 and 2007 had evidence of sedimentation. The remaining site's FCs ranged from 0.53 to 0.94.

3.6 Function 6: Export of Detritus

Definition:
Export of organic detritus from the wetland to adjacent and downstream aquatic ecosystems (Magee and Hollands 1998).

Model Results:

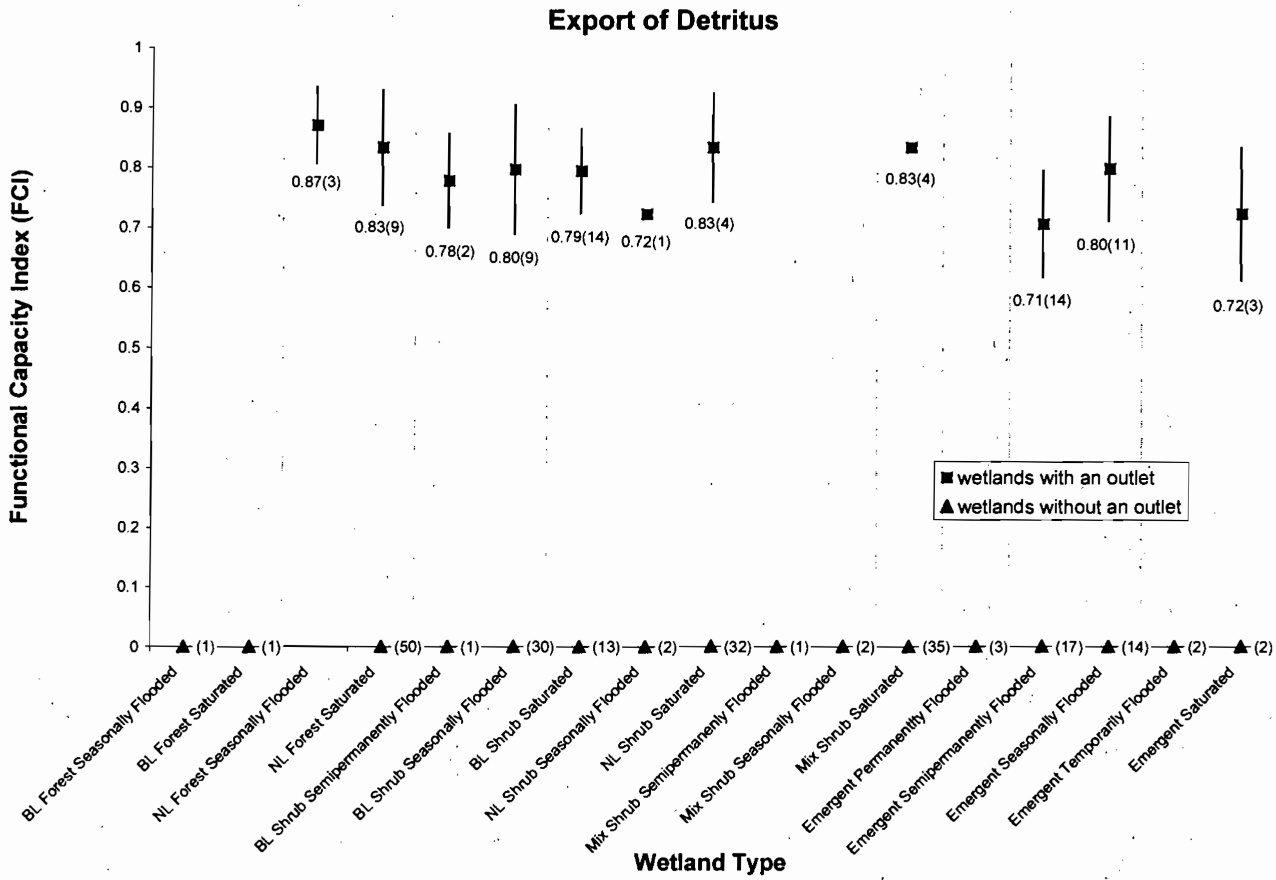

Table 9. Variables Used in Model Calculations for Export of Detritus

	Indicator of Disfunction	Direct Indicator of Function	Point Value
Outlet Class: No outlet	X		
Wetland land use			1-3
Degree of outlet restriction			1-3
Outlet Class: Perennial outlet Intermittent outlet			1-3
Wetland water regime			1-3
Vegetation density/dominance			0-3
Soil type			1-3

Discussion:

Some wetlands support high levels of net primary production (i.e., plant growth). When these wetlands flood or are adjacent to streams, nutrients and organic carbon are entrained in the stream's waters and are distributed to downstream waters and other wetlands. These nutrients and organic carbon can serve as a potential source of energy for downstream aquatic ecosystems and contribute to the support of their food chains. In the Tanana floodplain, carbon availability limits microbial activity which controls the availability of inorganic nutrients for plant production (Magoun and Dean 2000)

The model relates vegetation structure and community, as well as flow-through of surface water, to the ability of a wetland to perform this function. A direct indicator of disfunction for export of detritus is absence of an outlet. The 201 plots that did not have an outlet were given an FC of zero. The wetland plots that had an outlet are included in the graph and had individual FC values between 0.60 and 0.94. Overall, wetlands with an outlet had a high value for export of detritus.

3.7 Function 7: Contribution to Abundance and Diversity of Wetland Vegetation

Definition:
The capacity of a wetland to produce an abundance and diversity of hydrophytic plant species individually or as a part of a group of wetlands in a local landscape (Magee and Hollands 1998).

Model Results:

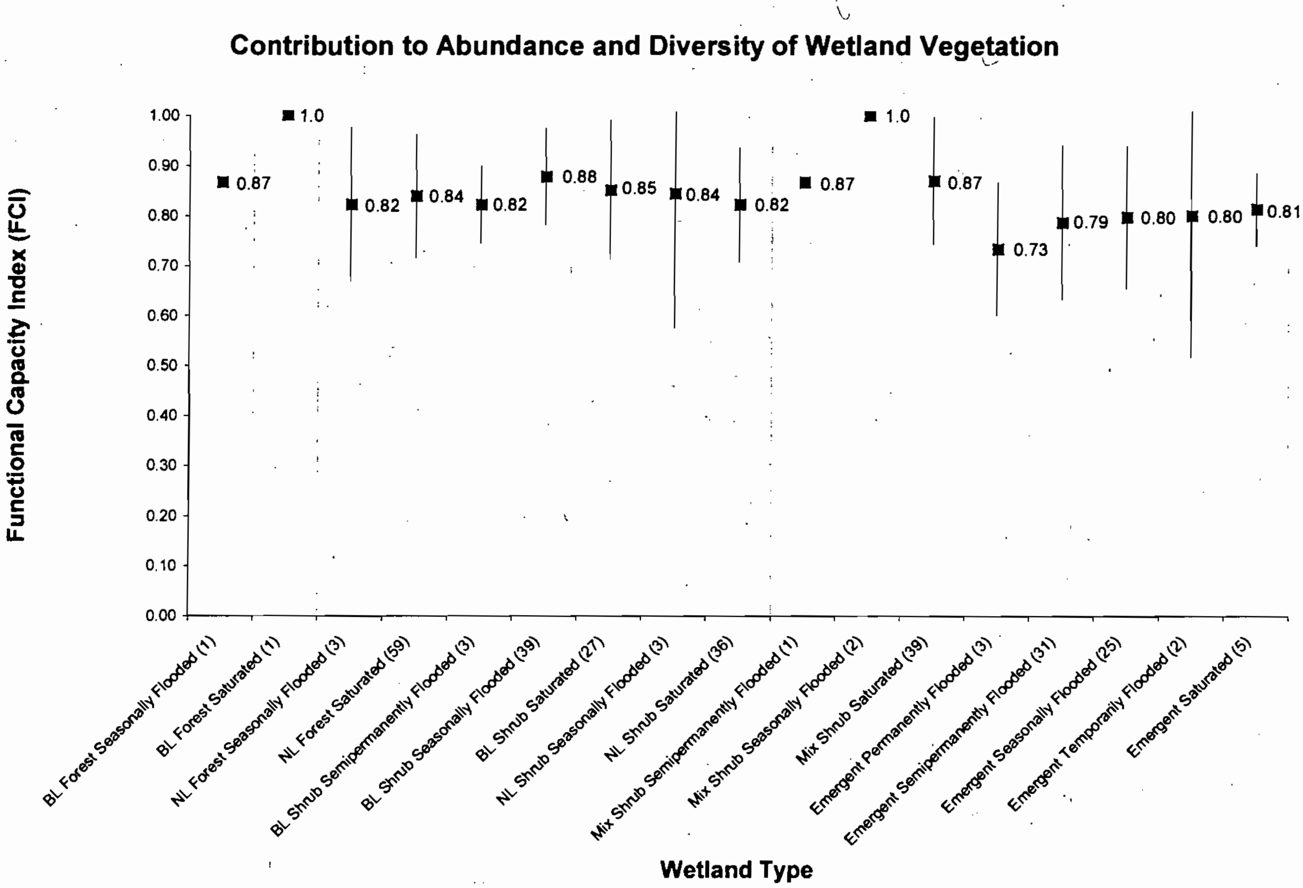

Table 10. Variables Used in Model Calculations for Contribution to Abundance and Diversity of Wetland Vegetation

	Indicator of Disfunction	Direct Indicator of Function	Point Value
No vegetation	X		
Plant species diversity			1-5
Vegetation density/dominance			1-5
Wetland Juxtaposition			1-5

Discussion:

The contribution to abundance and diversity of wetland vegetation model evaluates the species composition and physical characteristics of the surrounding plant community. The unique communities of vegetation that grow in the poorly drained soil of wetlands serve as a repository of genetic material and information for the component species that cannot be found elsewhere (Magee and Hollands 1998).

Factors that are important to this function include plant species diversity, vegetation density and dominance, and proximity to other wetlands. For the purpose of this model plant species diversity was considered low when 10 or fewer species were found and high when more than 18 species were found. There were no sites completely free of vegetation, which is a direct indicator of disfunction. The range of FC values for all wetland sites for this function was 0.40 to 1.0.

In general, all wetland types had high functional capacities. This function is measuring a wetland's potential to perform the function relative to the landscape which explains the relative close grouping of the FCs of all the wetland types. Because the study area contains wetlands within the same unaltered environment, it is expected that values for this function would be high and in a relatively narrow range.

3.8 Function 8: Contribution to Abundance and Diversity of Wetland Fauna

Definition:
The capacity of a wetland to support large and/or diverse populations of animal species that spend part or all of their life cycle in wetlands, individually, or as part of a mosaic of wetlands in a local landscape (Magee and Hollands 1998).

Model Results:

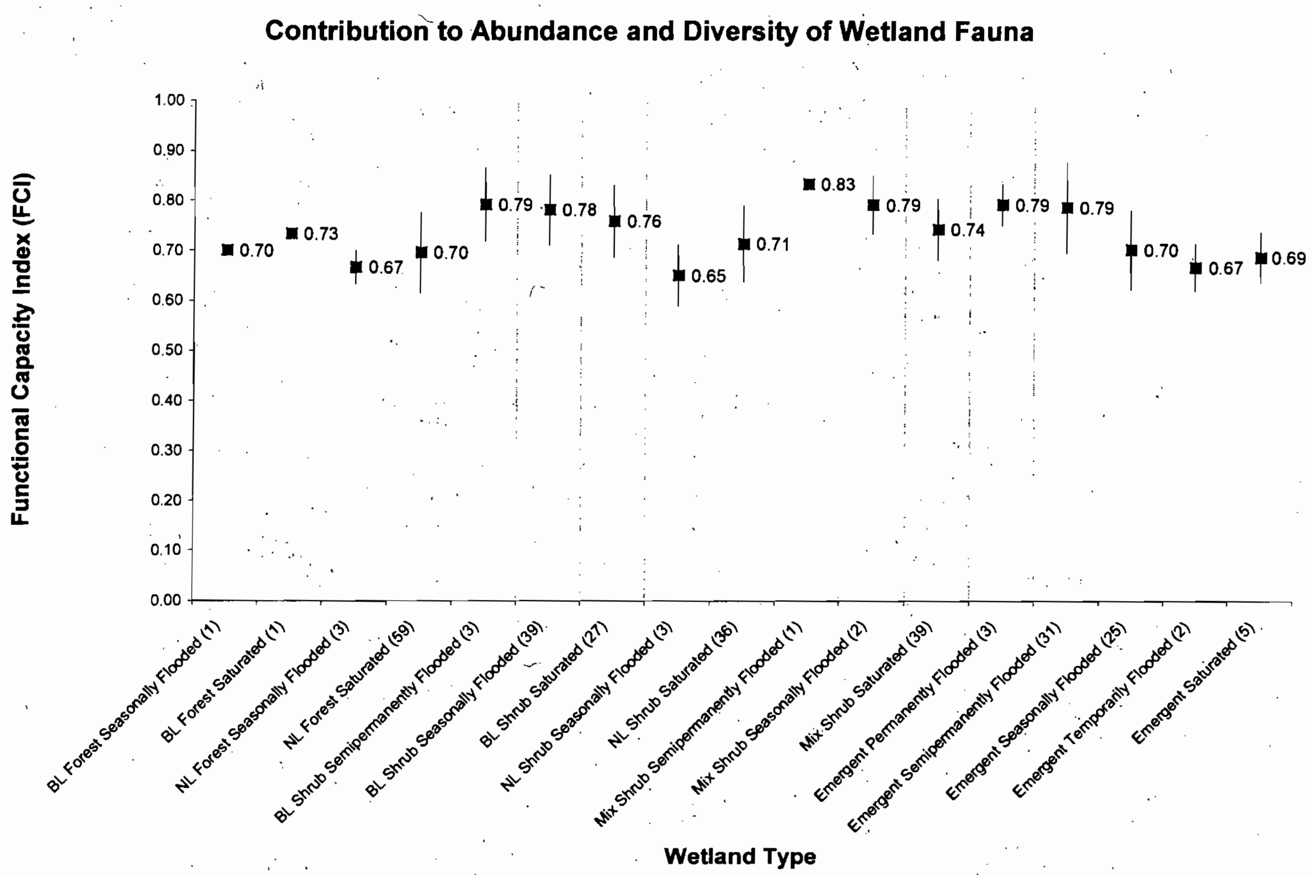

Table 11. Variables Used in Model Calculations for Contribution to Abundance and Diversity of Wetland Fauna

	Indicator of Disfunction	Direct Indicator of Function	Point Value
Watershed Land Use			1-3
Wetland Land Use			1-3
Wetland Water Regime			1-3
Microrelief of Wetland Surface			0-3
Vegetation Interspersion			0-3
Interspersion of Cover and Open Water			0-3
Size			1-3
Wetland Juxtaposition			0-3

Discussion:

This functional model assesses a wetland's capacity to contribute to the abundance and diversity of wetland fauna. Wetlands are unusually diverse because they support both terrestrial and aquatic biota (Batzer and Sharitz 2006). Wetlands support invertebrates, cold blooded vertebrates, and terrestrial mammals, such as moose that use wetlands on a seasonal basis (Post 1996). Water in the form of sloughs, ponds, and bogs and associated vegetated and unvegetated shorelines in the Tanana floodplain provide habitat for waterbirds, including shorebirds, waterfowl, gulls, terns, and sandhill cranes, contributing greatly to the species richness of the area (Magoun and Dean 2000). Common mammals that have a high probability of foraging and feeding in black spruce wetlands include: the common, pygmy, dusky, and northern water shrews; red squirrel; meadow jumping mouse; northern red-backed, tundra, meadow, and yellow-cheeked voles; northern bog lemming; porcupine; and snowshoe hare. The small insectivores and herbivores that occur in these wetlands support a vast array of larger carnivores that occur throughout the region (Post 1996).

Moose habitat in the area is abundant and depends, in part, on plant community composition, structure, successional stage and diversity. Large expanses of treed black spruce wetlands provide little habitat to moose. Moose habitat is better quality in interwoven patterns of forested and emergent wetlands that provide sheltered areas with access to food, isolated sites for calving and aquatic feeding areas (Magoun and Dean 2000). Alaska Department of Fish and Game (ADFG) has indicated that there is a high concentration of moose in the study area, particularly the northwest portion which is used as migration route and as a calving area (ADFG 2006).

To assess this function, the model looks at the structure and composition of the vegetation community and its spatial relationship to other plant communities and open water. The most important factor in this model is the wetland water regime, since it largely controls dominant vegetation and influences animal mobility and access to the wetland and to food sources. There are no direct indicators of function or disfunction.

All 281 wetland sites had an FC between 0.46 and 0.96, a relatively narrow band. This function assesses the ability of a wetland to contribute to wetland fauna on a landscape level. In the mostly pristine study area, a wetland's ability to perform this function corresponds directly to other area wetlands' ability to do the same. Therefore, a narrow range of values would be expected. The variation that does exist is primarily due to water regime, with wetter wetlands receiving higher values than the saturated and temporarily flooded wetlands.

4.0 Model Results by Region

In an agency meeting held on March 1, 2007 between HDR Alaska, Inc. and the USACE, the USACE suggested that the model results be stratified by region. To study model results by location, the study area was split into four regions (Figure 1). Region 1 contains the northern end of the study area east of the Tanana River. Region 2 contains the northern portion of the study area west of the Tanana River and north of Delta Creek. Region 3 is the smallest region and is situated on a bench just west of the Tanana River. Region 3 contains the alignment Donnelly West. Region 4 contains all other alignments south of Delta Creek.

Model results were calculated for all of the wetland types within each region. Although there were some small differences among regions, the majority of the regions had a FC mean very similar to the area-wide FC mean.

The model does not capture the differences in the FCs that may exist between the regions. This may be a limitation of the model or a limitation due to small sample sizes. Sample sizes drop dramatically when wetland plot locations are divided by wetland type, outlet status, and region. Individual variables that are entered into the model are already limited due to the homogeneity of the landscape. Regional stratification within the study area does not seem to impact any particular variable in the model enough to have disparate results.

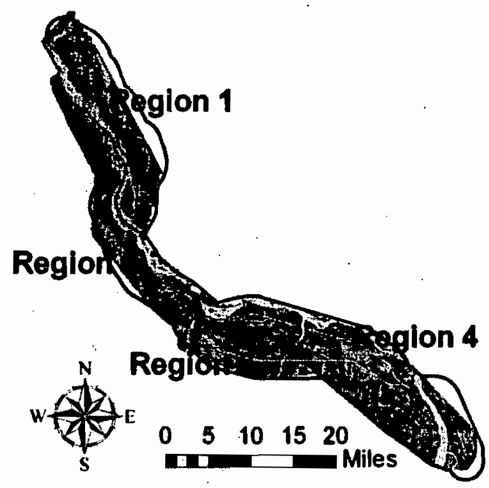

Figure 1. Study Area Regions

For further analysis, the model results were compared to each function without accounting for wetland type. The results are shown in Table 12. Means are closely related throughout the four regions. This shows that the variables in the model are not able to stratify the different regions in the study area.

Table 12. Comparison of Model Results by Region

	GW Discharge	GW Recharge	Storm and Flood Water Storage*	Mod. of Stream Flow*	Mod. of Water quality	Export of Detritus*	Contribution to Wetland Vegetation	Contribution to Wetland Fauna
Region 1	0.47	0.56	0.54	0.48	0.81	0.81	0.84	0.73
Region 2	0.57	0.46	0.54	0.59	0.81	0.73	0.85	0.76
Region 3	0.48	0.48	0.59	0.50	0.80	0.83	0.84	0.73
Region 4	0.50	0.52	0.56	0.53	0.80	0.79	0.83	0.73

*only wetlands with outlets included in model results

5.0 Models Results versus Other Sources

5.1 Existing Soil Survey Data

To compare the model's output for groundwater discharge and groundwater recharge to existing data, the functional data points were overlain with the current Natural Resource Conservation Service (NRCS) soil surveys for the Upper Tanana Area and the Greater Fairbanks Area (NRCS 1999 and 2004). The results are shown in Table 13.

Table 13. Comparison of Existing Soil Survey Data and Model Results

Soil Type	Slope (%)	Description of Soil	Permafrost	# of data points	Mod. of GW Dis.	Mod of GW Rec.
Goldstream and Histosols	0-3	DTP: 10-20"	Y	20	0.51	0.52
Goldstream peat	0-3	DTP: 14-24"	Y	15	0.52	0.47
Goldstream peat	3-7	DTP: 14-24"	Y	1	0.60	0.39
Goldstream-Tanana complex	0-3	Goldstream- DTP:10-20" Tanana- DTP:21-31"	Y	26	0.48	0.55
Tanana mucky silt loam	0-2	DTP: 16-47"	Y	1	0.40	0.52
Tanana silt loam	0-3	DTP: 20-40"	Y	28	0.51	0.49
Tanana, moderately wet-Goldstream complex	0-3	DTP: 40-60"	Y	3	0.40	0.59
Tanana, moderately wet-Goldstream complex	3-7	DTP: 40-60"	Y	1	0.27	0.67
Eielson-Tanana complex	0-2	Eielson- >40" loamy material over sand and gravel Tanana- Depth to Permafrost (DTP): 16-47"	Mix	1	0.47	0.61
Cryorthents, flooded	0-3	~18" loamy material over very coarse gravelly sand	N	1	0.33	0.78
Jarvis fine sandy loam	0-2	10-40" loamy material over sand and gravel	N	1	0.60	0.61
Jarvis-Fubar complex	0-7	sandy loam above sand and gravel	N	3	0.54	0.60
Koyukuk silt loam	3-7	~40" of silt and silt loam material to sand and gravel	N	2	0.39	0.52
Koyukuk silt loam	7-12	~40" of silt and silt loam material to sand and gravel	N	1	0.53	0.44
Nenana silt loam	0-3	<40" silt loam to sand	N	2	0.37	0.58
Nenana silt loam	3-7	<40" silt loam to sand	N	1	0.40	0.61
North Pole-Mosquito-Liscum complex	0-2	0-40" loamy material over sand and gravel	N	1	0.47	0.61
Salchaket very fine sandy loam	0-2	>40" loamy material over sand and gravel	N	1	0.47	0.61
Salchaket-Riverwash association	0-3	>40" loamy material over sand and gravel	N	3	0.53	0.45
Steese-Ester association	12-45	20-40" silt and sand loam to unconsolidated bedrock	N	4	0.72	0.26
Water			N	1	0.47	0.61

Although the data are at different scales, with extremely site specific functional data collected by the Magee and Hollands method and much broader-scale information reflected by the soil classification, some trends are apparent. The higher average FC values occur in the soil types that are not underlain by permafrost. Of the soil types that have an average FC above 0.60 for either groundwater discharge or groundwater recharge, 89% are underlain by permafrost. Approximately 10% of the individual wetland sites that the soil survey indicated had permeable soil had an FC of 1.0 in either the groundwater discharge or recharge function. Only 5% of sites underlain by permafrost received a 1.0 in either function. Wetlands above permeable ground would be expected to have a much higher chance of discharging or recharging groundwater because they have a direct connection to subsurface groundwater. This analysis corroborates the validity of the model's results for groundwater discharge and recharge.

5.2 Best Professional Judgment

In 2005, functional data were collected using the Magee and Hollands Wetland Inventory Data form. In 2006 and 2007, a revised wetland functional form was used that included many of the Magee and Hollands questions and a BPJ section. In this section, the wetland scientist would check off which of eight functions the wetland was performing and explain his/her choices. The eight functions included:

- groundwater discharge
- groundwater recharge
- streamflow moderation
- shoreline stabilization
- pollutant removal and retention - effectiveness
- pollutant removal and retention - opportunity
- primary production and carbon export
- fish and wildlife habitat

Six of the functions directly correspond to functions in the Magee and Hollands model. Two of the functions (shoreline stabilization and pollutant removal and retention-opportunity) do not correlate with the model and are not included in this analysis.

Table 14. Comparison of BPJ to Model Results

Wetland Function	Judged as Performing Function		Judged as not Performing Function		Difference Between Average FCs of Sites Judged as Performing and not Performing this Function
	# of Sites	Average FC	# of Sites	Average FC	
Groundwater Discharge	41	0.67	240	0.45	0.22
Groundwater Recharge	21	0.48	260	0.52	-0.04
Modification of Stream Flow (Streamflow Moderation)	22	0.47	259	0.05	0.42
Modification of Water Quality (Pollutant Removal and Retention-Effectiveness)	71	0.82	210	0.81	0.01
Export of Detritus (Primary Production and Carbon Export)	47	0.37	234	0.09	0.28
Contribution to the Abundance and Diversity of Wetland Fauna (Fish and Wildlife Habitat)	102	0.76	179	0.72	0.04

In order to compare BPJ to the model results, the average FCs of the sites that were judged to be performing the function were compared to the average FCs of the sites judged as not performing the function (Table 14). These averages were compared to see if there was a relationship between the scientists' judgment and the model results. The table shows that there is a strong similarity between what the scientist perceives in the field and the model results for the functions groundwater discharge, modification of stream flow, and export of detritus. Functional values across wetlands within the study area were similar, making differences in FCs greater than 0.20 seem meaningful.

The FC of the sites judged to perform groundwater recharge was less than the average of the sites not judged to perform this function. The reason for this discrepancy is in the difference between how the wetland scientist and the model view this function. At 11 sites, the wetland scientist checked both groundwater discharge and groundwater recharge as occurring at the site. However, the model assumes that if one function occurs it is prohibitive of the other. Two of the sites that were marked as both groundwater discharge and groundwater recharge sites ended up with a model value of 1.0 for groundwater discharge and 0 for groundwater recharge. Without nested piezometer data it is extremely difficult to know if a particular wetland is recharging groundwater.

The remaining two functions that showed minimal FC differences between the wetlands that were judged to perform the functions and the ones that were not are modification of water quality and contribution to the abundance and diversity of wetland fauna. Both of these functions occur in a narrow band with little variation in functional capacity indices across the study area. The small variations across all data collection sites explain why the model results for BPJ sites are only slightly higher than the mean FCs of the remaining sites.

6.0 Conclusion

The Magee and Hollands model is a useful tool for analyzing wetlands and their associated functions. The model provides a method of determining which functions a wetland most likely performs. Although the FCs are nominal, they can be useful to compare and relate wetland functions among the different wetland types.

The purpose of this report is to compare project area wetlands among themselves, with the goal of identifying which wetlands within the study area are potentially more valuable. To do this, the results of the model must be modified in conjunction with this goal.

The model asserts that all wetlands have a relationship with groundwater. This manifests itself in the FC for groundwater discharge and groundwater recharge for any particular wetland totaling approximately 1. The model is stating that if it is not discharging groundwater at any given time, then it must be recharging groundwater. If both functions were used to compare project area wetlands, then the values would cancel each other out. Therefore, only one of the groundwater functions should be considered when comparing wetlands throughout the study area. The comparison between the groundwater discharge and recharge functions to the BPJ of the wetland scientist in the field showed that the model results correlated more accurately for the groundwater discharge function than the groundwater recharge function. Therefore, groundwater discharge is considered when comparing project area wetlands to each other and not groundwater recharge.

The relative homogeneity of the study area also plays a role in the limited range of some of the functions. The wetlands are all in the same general area with identical climatic conditions and very little disturbance to the wetlands or surrounding ecosystems. The broader based functions which are measuring a wetland's potential relative to the landscape as a whole show very little variation among wetland types. This is apparent in the functions modification of water quality, contribution to the abundance and diversity of wetland vegetation, and contribution to the abundance and diversity of wetland fauna. The FC indices of these functions show how wetlands on the whole are functioning in the environment. These functions would be useful in comparing the Tanana Valley wetlands to wetlands in other locations; however they do not meet the objective of this study. In accordance with the purpose of this report, these functions were removed from the comparative analysis.

The three remaining functions, storm and flood water storage, modification of stream flow, and export of detritus, are heavily influenced by the relationship of the wetland to a stream. Each one of these functions has the absence of an outlet either as a direct indicator of disfunction or as a direct indicator of function, giving these sites either a 0 or 1 FC. The absence of an outlet is a much more important variable than are the vegetation and hydrologic regimes characteristics that define Cowardin *et al.* (1979) wetland types. FCs for these three functions are dependent first on the proximity to a stream and less so on the wetland type. These functions remained in the analysis because they differentiate among project area wetlands. The modification of stream flow and export of detritus functions are also strongly supported by the BPJ of wetland scientists onsite.

Overall, the following conclusions can be applied to the study area wetlands using the Magee and Hollands model:

- Permanently and semipermanently flooded wetlands have a high FC to perform groundwater discharge. All remaining wetlands have a moderate FC to perform this function.

- Wetlands without an outlet have a high FC to store storm and floodwater, while all others have a moderate FC to perform this function.

- Permanently and semipermanently flooded wetlands with an outlet have a high FC to modify stream flow, while all other wetlands with an outlet have a moderate FC to perform this function.

- Wetlands with an outlet have a high FC to export detritus.

- Wetlands without an outlet have a low FC to modify stream flow and to export detritus.

The purpose of this functional assessment is to compare wetlands within the study area relative to one another. The functions which provide differentiation among study area wetlands and have been correlated with scientists' BPJ, are Groundwater Discharge, Export of Detritus, and Modification of Stream Flow. To apply the Magee and Hollands functional assessment method to the entire study area corridor, these functions, along with the function storm and floodwater storage, have been attributed to all of the wetlands in the study corridor. This was done based on the wetlands' water regime and outlet status. Table 15 shows the model results for all of the wetland types within the Northern Rail Extension Project corridor. If data were not available for a specific wetland type, it was extrapolated from a similar wetland type.

Table 15. Wetland Functional Assessment Summary – Average Functional Capacity of Wetland Type by Water Regime

Vegetated Wetland Type by Water Regime	# of Data Points	Area (acres)			Modification of Groundwater Discharge	Storm and Flood Water Storage (wetlands with an outlet)	Storm and Flood Water Storage (wetlands without an outlet)	Mod. of Stream Flow (wetlands with an outlet)	Mod. of Stream Flow (wetlands without an outlet)	Export of Detritus (wetlands with an outlet)	Export of Detritus (wetlands without an outlet)
		With Outlet	Without Outlet	Total							
Permanently Flooded	3	3	83	86	High	Mod[1]	High	High[1]	Low	High[1]	Low
Semipermanently Flooded	35	59	181	239	High	Mod	High	High	Low	High	Low
Seasonally Flooded	73	284	1,344	1,627	Mod	Mod	High	Mod	Low	High	Low
Saturated	167	346	6,638	6,985	Mod	Mod	High	Mod	Low	High	Low
Temporarily Flooded	2	27	14	41	Mod	Mod[2]	High	Mod[2]	Low	High[2]	Low

[1] Extrapolated from Semipermanently Flooded Wetlands
[2] Extrapolated from Saturated Wetlands

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Appendix A

HGM (MAGEE AND HOLLANDS) FUNCTIONAL MODELS

Northern Rail Extension Project
Wetland Functional Assessment

Groundwater Discharge VARIABLES	CONDITIONS	WEIGHT
Indicators of Disfunction		
Inlet/Outlet Class	• perennial inlet/no outlet	0
Direct Indicators of Function		
Presence of Seeps and Springs	• evidence of perennial seeps or springs	18
Inlet/Outlet Class	• no inlet/perennial outlet	18
Primary Variables		
Microrelief of Wetland Surface	• pronounced	3
	• well developed	2
	• poorly developed	1
	• absent	0
Inlet/Outlet Class	• perennial inlet/perennial outlet	3
	• intermittent inlet/perennial outlet	2
	• all other classes	0
pH	• alkaline	3
	• circumneatral	2
	• acid	0
	• no water present	0
Surficial Geologic Deposit Under Wetland	• high permeability stratified deposits	3
	• low permeability stratified deposits	2
	• glacial till	1
Wetland Water Regime	• wet; permanently flooded, intermittently exposed, semipermanently flooded	3
	• drier; seasonally flooded, temporarily flooded, saturated	1
Soil Type	• histosol	3
	• mineral hydric soil	1

Groundwater Recharge		
VARIABLES	CONDITIONS	WEIGHT
Indicators of Disfunction		
Inlet/Outlet Class	• no inlet/perennial outlet	0
	• intermittent inlet/perennial outlet	0
Presence of Seeps and Springs	• evidence of perennial seeps or springs	0
Direct Indicators of Function		
Inlet/Outlet Class	• perennial inlet/no outlet	21
Primary Variables		
Microrelief of Wetland Surface	• poorly developed	3
	• absent	3
	• well developed	2
	• pronounced	1
Inlet/Outlet Class	• perennial inlet/intermittent outlet	3
	• all other classes	0
pH	• acid	3
	• circumneutral	2
	• alkaline	1
	• no water present	0
Surficial Geologic Deposit Under Wetland	• glacial till	3
	• low permeability stratified deposits	2
	• high permeability stratified deposits	1
Surface Water Level Fluctuation	• high fluctuation	3
	• low fluctuation	2
	• never inundated	1
Wetland Water Regime	• drier; seasonally flooded, temporarily flooded, saturated	3
	• wet; permanently flooded, intermittently exposed, semipermanently flooded	1
Soil Type	• gravelly or sandy mineral hydric	3
	• silty or clayey mineral hydric	2
	• sapric histosol	1
	• fibric or hemic histosol	0

Storm and Flood-Water Storage VARIABLES	CONDITIONS	WEIGHT
Direct Indicators of Function		
Inlet/Outlet Class	• no outlet	30
Primary Variables		
Inlet/Outlet Class	• perennial inlet/intermittent outlet	3
	• intermittent inlet/intermittent outlet	2
	• no inlet/intermittent outlet	1
	• non inlet/perennial outlet	1
	• intermittent inlet/perennial outlet	1
	• perennial inlet/perennial outlet	1
Degree of Outlet Restriction	• restricted	3
	• unrestricted	0
Basin Topographic Gradient	• low gradient	3
	• high gradient	1
Wetland Water Regime	• drier: seasonally flooded, temporarily flooded, saturated	3
	• wet: permanently flooded, intermittently exposed, semipermanently flooded	1
Surface Water Level Fluctuation of the Wetland	• high fluctuation	3
	• low fluctuation	2
	• never inundated	0
Ratio of Wetland Area to Watershed Area	• large	3
	• small	1
Microrelief of Wetland Surface	• pronounced	3
	• well developed	2
	• poorly developed	1
	• absent	0
Frequency of Overbank Flooding	• overbank flooding absent	0
	• return interval of >5 years	1
	• return interval of 2-5 years	2
	• return interval of 1-2 years	3
Vegetation Density/Dominance	• high/very high density	3
	• moderate density	2
	• sparse/low density	1
	• no vegetation	0

Storm and Flood-Water Storage *(continued)*

VARIABLES	CONDITIONS	WEIGHT
Primary Variables		
Dead Woody Material	• abundant	3
	• moderately abundant	2
	• sparse	1
	• absent	0

Modification of Stream Flow

VARIABLES	CONDITIONS	WEIGHT
Indicators of Disfunction		
Inlet/Outlet Class	• no outlet	0

Primary Variables

Storm and Flood-Water Storage Function Model Score			Modification of Groundwater Discharge Function Model Score			
High	3	x	High	3	=	9
Mod	2	x	High	3	=	6
Low	1	x	High	3	=	3
High	3	x	Mod	2	=	6
Mod	2	x	Mod	2	=	4
Low	1	x	Mod	2	=	2
High	3	x	Low	1	=	3
Mod	2	x	Low	1	=	2
Low	1	x	Low	1	=	1

Modification of Water Quality

VARIABLES	CONDITIONS	WEIGHT
Direct Indicators of Function		
Evidence of Sedimentation	• sediment observed on wetland substrate	18
	• fluvaquent soils	18
Primary Variables		
Wetland Land Use	• low intensity	3
	• moderate intensity	2
	• high intensity	1
Degree of Outlet Restriction	• restricted outflow	3
	• no outlet	2
	• unrestricted outflow	1

Modification of Water Quality *(continued)*		
VARIABLES	CONDITIONS	WEIGHT
Primary Variables		
Inlet/Outlet Type	• no outlet	3
	• intermittent outlet	2
	• perennial outlet	1
Dominant Wetland Type	• forested wetland	3
	• scrub-shrub	2
	• emergent wetland	2
	• aquatic bed	0
	• no vegetation	0
Cover Distribution	• forming a continuous cover	3
	• growing in small scattered patches	2
	• one or more large patches	1
	• solitary scattered stems	1
	• no vegetation	0
Soil Type	• histosol or clayey soil	3
	• silty soil	2
	• sandy or gravelly soil	1

Export of Detritus		
VARIABLES	CONDITIONS	WEIGHT
Indicators of Disfunction		
Inlet/Outlet Class	• no outlet	0
Primary Variables		
Wetland Land Use	• moderate intensity	3
	• low intensity	2
	• high intensity	1
Degree of Outlet Restriction	• unrestricted outflow	3
	• restricted outflow	1
Inlet/Outlet Class	• perennial outlet	3
	• intermittent outlet	1
Wetland Water Regime	• drier: seasonally flooded, temporarily flooded, saturated	3
	• wet: permanently flooded, intermittently exposed, semipermanently flooded	1

Export of Detritus *(continued)*		
VARIABLES	CONDITIONS	WEIGHT
Primary Variables		
Vegetation Density/Dominance	• high/very high density	3
	• medium density	2
	• sparse/low density	1
	• no vegetation	0
Soil Type	• mineral hydric soil	3
	• histosol	1

Contribution to Abundance and Diversity of Wetland Vegetation		
VARIABLES	CONDITIONS	WEIGHT
Indicators of Disfunction		
Dominant Vegetation Type	• no vegetation	0
Primary Variables		
Plant Species Diversity	• high diversity	5
	• medium diversity	3
	• low diversity	1
Vegetation Density/Dominance	• high/very high density	5
	• medium density	3
	• sparse/low density	1
Wetland Juxtaposition	• connected upstream and downstream	5
	• connected above or below	3
	• other wetlands nearby but not connected (400 m or closer)	1
	• isolated	0

Contribution to Abundance and Diversity of Wetland Fauna		
VARIABLES	CONDITIONS	WEIGHT
Primary Variables		
Watershed Land Use	• low intensity (0-25% urbanized)	3
	• moderate intensity (25-50% urbanized)	2
	• high intensity (>50% urbanized)	1
Wetland Land Use	• low intensity	3
	• moderate intensity	2
	• high intensity	1
Wetland Water Regime	• wet: permanently flooded, intermittently exposed, semipermanently flooded	3
	• drier: seasonally flooded, temporarily flooded, saturated	1

Contribution to Abundance and Diversity of Wetland Fauna *(continued)*		
VARIABLES	CONDITIONS	WEIGHT
Primary Variables		
Microrelief of Wetland Surface	• pronounced	3
	• well developed	2
	• poorly developed	1
	• absent	0
Number of Wetland Types	• 5 or more types	3
	• 3-4 types	2
	• 1-2 types	1
	• no vegetation	0
Relative Proportions	• even distribution	3
	• moderately even distribution	2
	• highly uneven distribution	1
	• no vegetation	0
Vegetation Interspersion	• high interspersion	3
	• moderate interspersion	2
	• low interspersion	1
	• no vegetation	0
Number of Layers	• 5 or more layers	3
	• 3-4 layers	2
	• 1-2 layers	1
	• no vegetation	0
Percent Cover	• layers well developed (>50% cover)	3
	• layers with moderate cover (26-50% cover)	2
	• layers poorly distinguishable (<25% cover)	1
	• no vegetation	0
Interspersion of Vegetation Cover and Open Water	• 26-75% scattered or peripheral	3
	• >75% scattered or peripheral	2
	• <25% scattered or peripheral	1
	• 100% cover or open water	1
	• no vegetation	0
Size	• large (>100 acres)	3
	• medium (10-100 acres)	2
	• small (<10 acres)	1
Wetland Juxtaposition	• other wetlands within 400 m and connected above or below	3
	• other wetlands within 400 m but not connected	1
	• wetland isolated	0